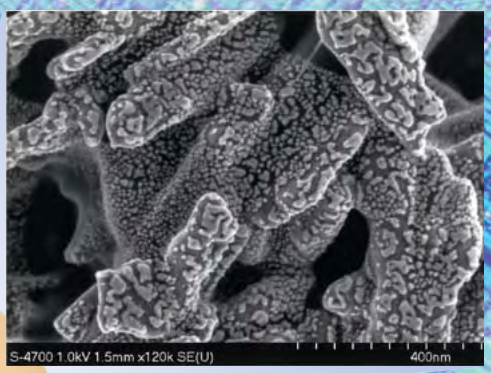
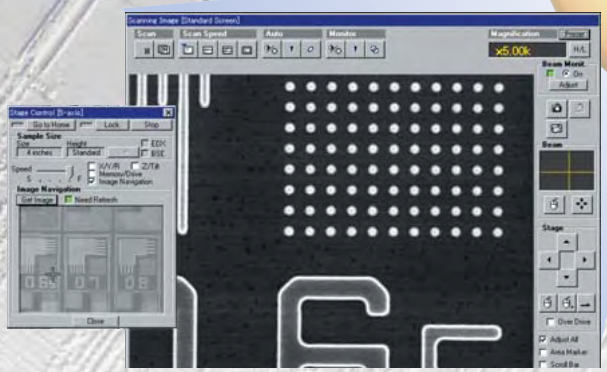
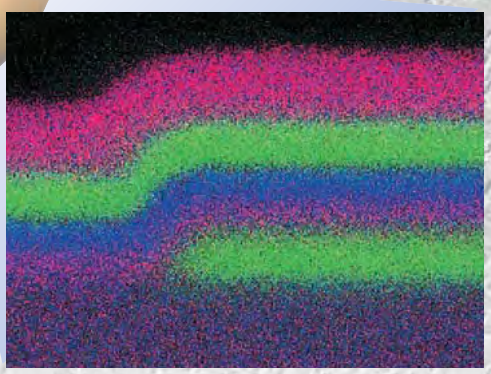
Hitachi High-Technologies

# S-4700

## Cold Field Emission
## Scanning Electron Microscope





HITACHI

# Windows® B

# S-4

## S-4700 Type II

## Introduction:

*There is a reason why experienced electron microscopists choose Hitachi more than any other brand. For more than 30 years, Hitachi has been delivering high quality, durable cold field emission electron microscopes that are dependable in producing exceptional micrographs that scientists continue to admire over the years.*

*Whether you are an electron microscopist investigating the latest semiconductor devices, a materials scientist working on advanced materials, or a biologist working with animal, plant, or tissue cells, there is a Hitachi CFE-SEM you can trust to produce your most important micrograph.*

*Want to make every single shot perfect? Choose the Hitachi S-4700. The S-4700 provides users with a comfortable GUI utilizing the familiar Windows* operating system. With its high-density frame memory of 2,560 × 1,920 pixels (maximum), you can be assured of superior image recording and storage. A variety of image formats, including BMP, TIFF, and JPEG, are available to suit your data handling requirements.*

*The S-4700 is available with two types of specimen stages; large or small. Either stage can be chosen to fit the user's specimens and applications. Further details are available on pages 11 and 14.*

*The S-4700 is not just a stand-alone instrument. Its flexible design will allow the user to transfer images between external systems using standard networking protocols (option). The addition of energy dispersive X-Ray spectrometer systems turns the S-4700 into a completely integrated SEM system. The unique "Hi-Mouse" software incorporates the S-4700 and any EDS system by allowing control of both systems using one keyboard and one mouse. This integrated SEM system offers a total analytical microscopy tool even for the most discriminate user.*

* Windows is a registered trademark of Microsoft Corporation, U.S.A.

# ased PC-SEM
# 700

S-4700 Type I

## Features:

### 1 High resolution at low accelerating voltage

- 2.1 nm resolution guaranteed at 1 kV

### 2 Routine microscopy at a long working distance of 12 mm

- Allowing sample exchange via airlock without repositioning
- High resolution of 1.5 nm at 15 kV
- Sample tilt of 45 degrees without change of working distance
- High X-ray take-off angle of 30 degrees with the sample normal to the beam
- Convenient and useful beam shift of ±15 microns

### 3 Integrated electron detector for both SE and BSE with signal manipulation design

- Operators can choose SE, BSE or both of them for the best imaging of their samples

### 4 Complete column set-up through the computer

- Without having to change the objective aperture, the operator simply switches between ultra high resolution mode and analysis mode through the click of a mouse

### 5 Unique objective lens design permits simultaneous use of YAG type BSE and EDX detector

Photo includes optional items.

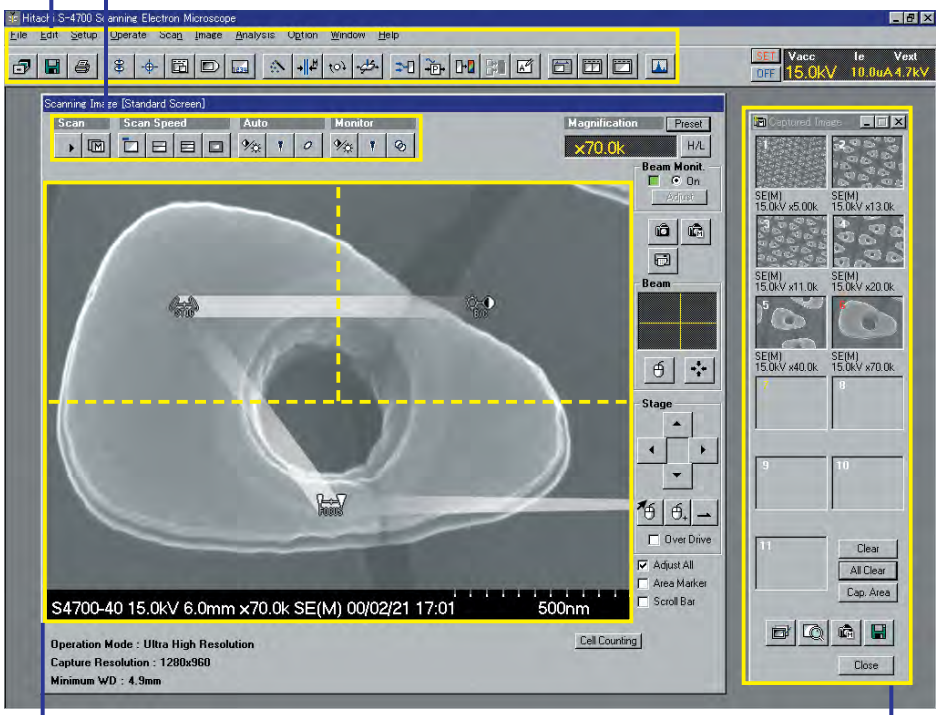
# Windows* Operating System

*The S-4700 has been developed so that both the image display and SEM parameters are directly on the computer monitor.*

*Shown below is a typical screen display utilizing Windows. All control buttons are logically grouped and laid out in a row.*

**1 Tool buttons**

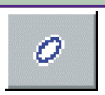
**2 Scan speed, Auto functions, and Screen mode selection**




**3 Focus, stigmation, and image brightness & contrast areas**

**4 "Captured Image Window" for transferring photo data and SEM images into memory**

*The mouse is used to select and adjust these controls, thereby adjusting the SEM image. The image itself is divided into three regions; one for stigmation correction, one for image brightness & contrast, and one for focus (coarse and fine) controls. These parameters are adjusted by simply clicking and dragging the mouse when it is positioned in the appropriate region. In each of these areas the cursor will change its shape to indicate the respective function. Additionally, when the cursor is positioned in the center of the screen the beam shift (one click) or stage movement (two clicks) will be enabled. For those who prefer it, a small control panel is standard. The rotary knobs on this panel address stigmation/alignment, focussing (coarse and fine), brightness/contrast, electrical image shift, and magnification. Optionally, an expanded control panel is available that encompasses fully conventional analog controls. Those who are familiar with the Hitachi S-4000 series SEM would find this option convenient and useful. The S-4700 has a standard screen mode (shown at left) as well as full and dual screen modes. These added modes display high-density images of 1,024 × 700 pixels on a full screen or two images (such as SE and BSE) simultaneously on the same screen. This unique display system allows versatile operation and observation of specimen images.*

| Functions | Autobutton | Mouse cursor |
|---|---|---|
| Stigmation |  |  |
| Brightness contrast |  |  |
| Focus |  |  |

# Image navigation mode

*Many applications require imaging of very small features. In order to simplify the search for particular points, the S-4700 includes an image navigation procedure. This entails capturing an image at a low magnification (see bottom right corner of display) and specifying the area of interest using the cursor. This area will then be centered so the operator can simply raise the magnification for a clear view of the feature. This image can be used for image navigation even after changing the magnification or moving the sample. Additionally, up to 100 points of interest can be stored and named for later recall.*

### *Image Acquisition*

### *Close-up Image of the Click Area*

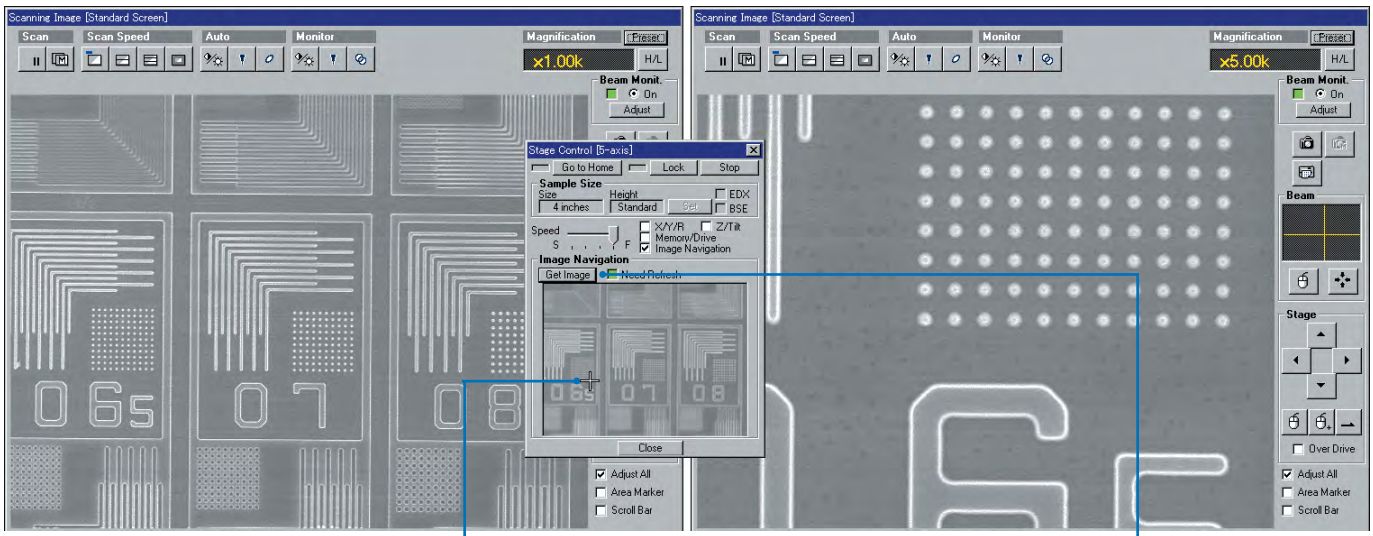
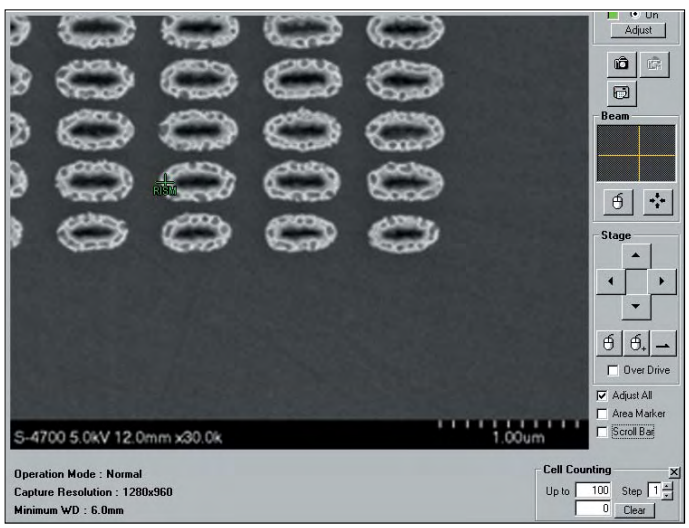


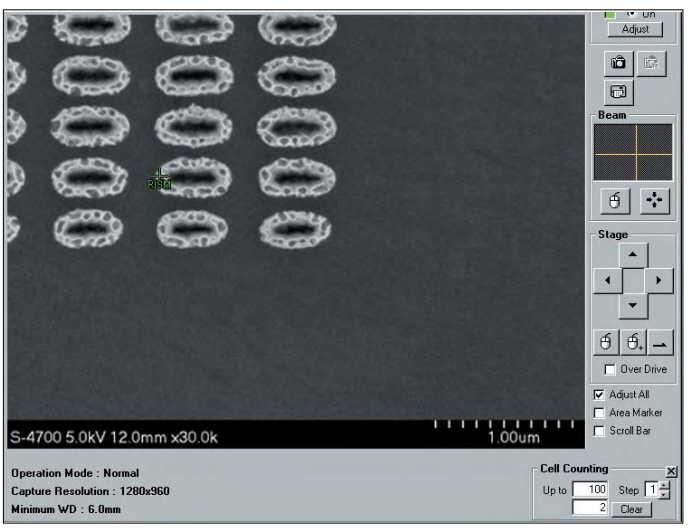

IMAGE NAVIGATION
Click here
Area of interest is centered in the Scanning Image window by placing the cross-hair cursor on it, and clicking the mouse button.

IMAGE ACQUISITION
Push this button

# Cell count mode

*The cell count mode is particularly convenient and useful for microscopy of semiconductor memory cells. It allows automated counting of cells in conjunction with RISM (Rapid Image Shift Mode) and notifies the operator when a preset number of cells has been counted on the viewing screen.*

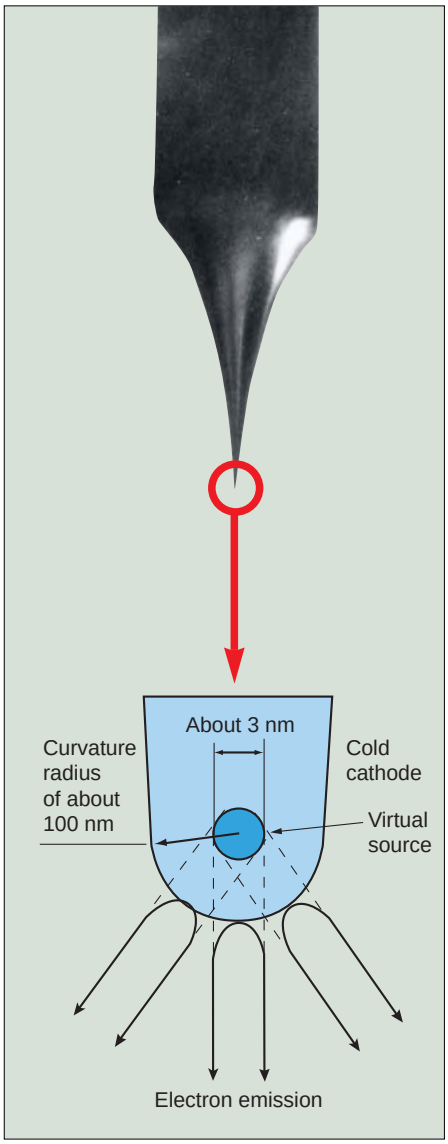


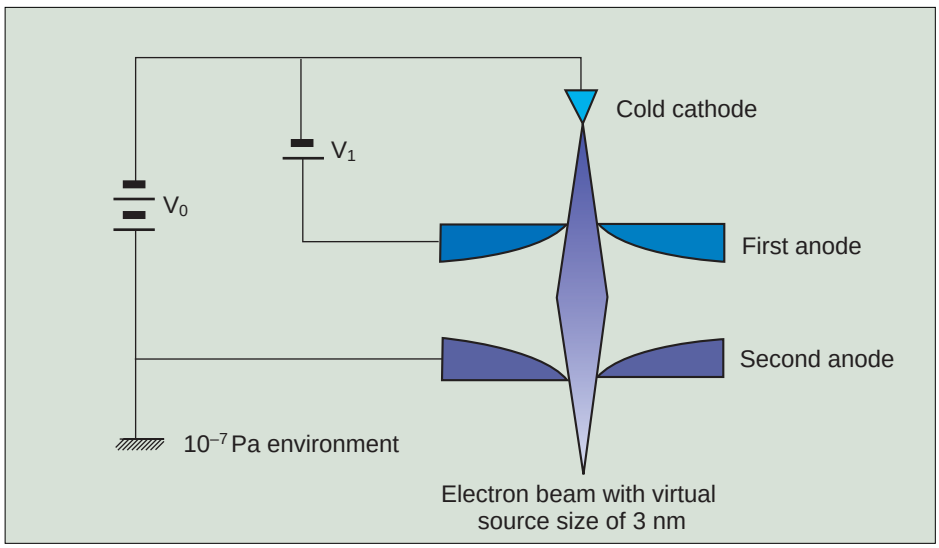
# The Cold Field Emission Electron Source

*The S-4700 operates using a cold field emission electron source. The CFE source consists of a pointed cathode and two anodes. The cathode itseif is made of a single crystal tungsten tip polished to a 100 nm radius of curvature. A voltage of several kilovolts ($V_1$) is applied across the cathode and the first anode, inducing electron emission from the tip that causes a strong field effect. The emission intensity is on the order of $10^9$ A/cm$^2$/sr (at 100 kV) which is surprisingly high compared to that of a conventional thermionic source such as a tungsten hairpin type filament ($10^6$ A/cm$^2$ /sr). The electrons emitted from the tip pass through the first anode and are accelerated by the second anode voltage ($V_0$), providing an electron source as small as 3 nm in diameter. Sufficient current for high resolution, with a good signal-to-noise ration, is available due to the high emission intensity provided by field emission.*

### Cold field emitter




### Principle of cold field emission electron source




*The table below is a comparison of various SEM electron sources. It is obvious that the cold field emission suppplies an optimum set of operating parameters and is the most promising electron source for ultra-high resolution microscopy, specifically in terms of source brightness, source size, emission current, energy spread and service life.*

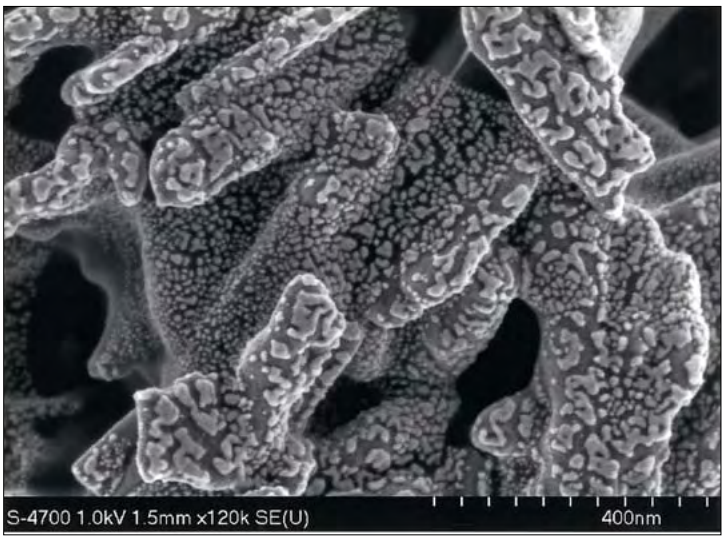
### Comparison of various electron source properties

| Source properties | CFE (Cold FE) W (310) | SE (Schottky Emission) ZrO/W | Primary contribution in application |
|---|---|---|---|
| Virtual source size $d_V$ (nm) | 2.5 to 3.5 | 15 to 30 | High resolution work |
| Energy spread (eV) | 0.2 to 0.3 | 0.3 to 1.0 | High resolution work |
| Beam fluctuation (%) | 4 to 6 | 0.1 to 1 | Analytical work |
| Emission current/solid angle I' (mA/sr) | <0.1 | 0.1 to 1 | Analytical work |
| Source brightness $B = 4I'/\pi\, d_v^2$ (A/cm$^2$sr) | $<2 \times 10^9$ | $2 \times 10^7 \sim 5 \times 10^8$ | High resolution work |
| Tip activation | Needed at time of use | Needed continuously | Maintenance cost |
| Typical service life | ~2 years | 8 months ~ 1 year | (CFE is less expensive) |

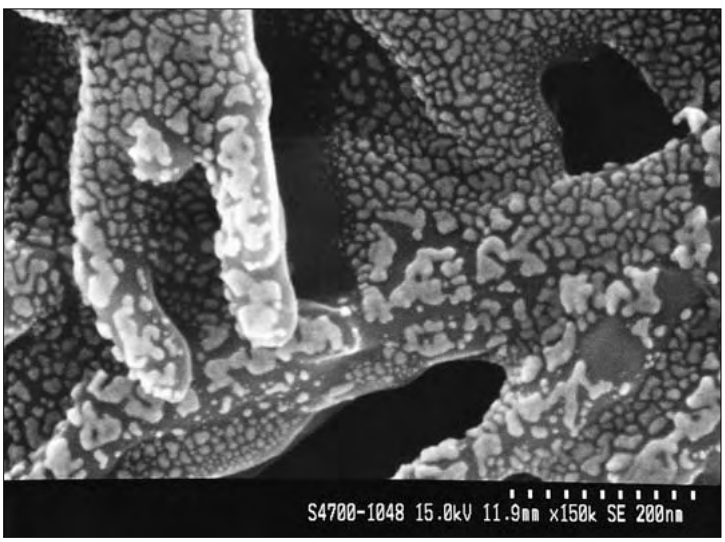
# High Resolution Imaging

S-4700

*The S-4700 has a new snorkel objective lens, designed with the latest electron optics theory. Providing 2.1 nm resolution at an accelerating voltage of 1 kV, the S-4700 is nealy equivalent to in-lens SEMs such as the Hitachi S-900 or S-5000. The S-4700 operates extremely well not only at low accelerating voltages, but also under large probe current conditions, long working distances, and high voltages. Various types of samples – including ferromagnetic materials – can easily be observed using the S-4700. The S-4700 is unique in that it provides high performance at relatively long working distances. At 12 mm, the sample exchange position, the S-4700 guarantees high resolution imaging (1.5 nm at 15 kv). Additionally, tilting up to 45 degrees and EDX analysis is available at 12 mm. Shown below is a diagram of the objective lens and specimen geometry. At left are typical resolution test micrographs taken at working distances of 1.5 mm and 12 mm, respectively. From these images it is clear that the high resolution imaging of the Hitachi S-4700 is unsurpassable.*

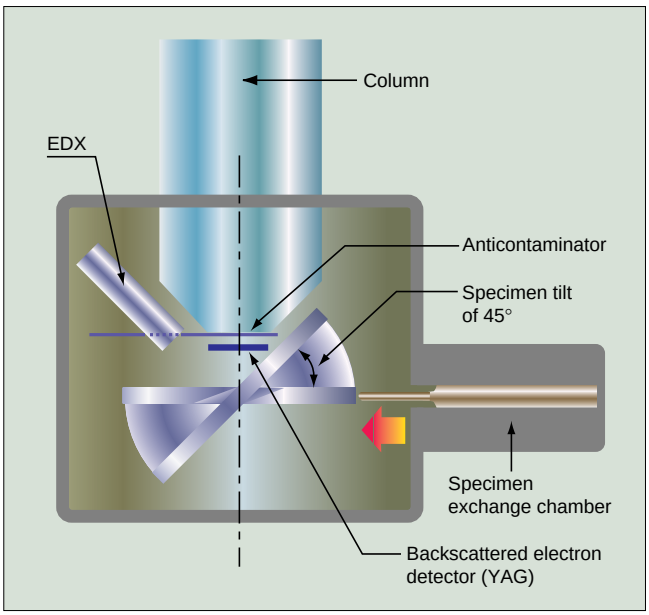


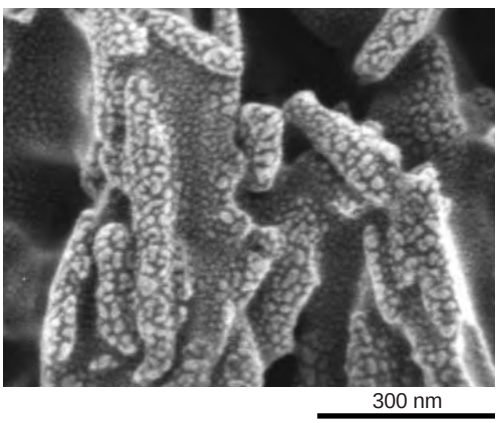

*High resolution micrograph of gold coated magnetic tape, recorded at 1 kV and WD of 1.5 mm*




*High resolution micrograph of gold coated magnetic tape, recorded at 15 kV and WD of 12 mm (specimen exchange position)*

### *The objective lens and specimen position geometry*



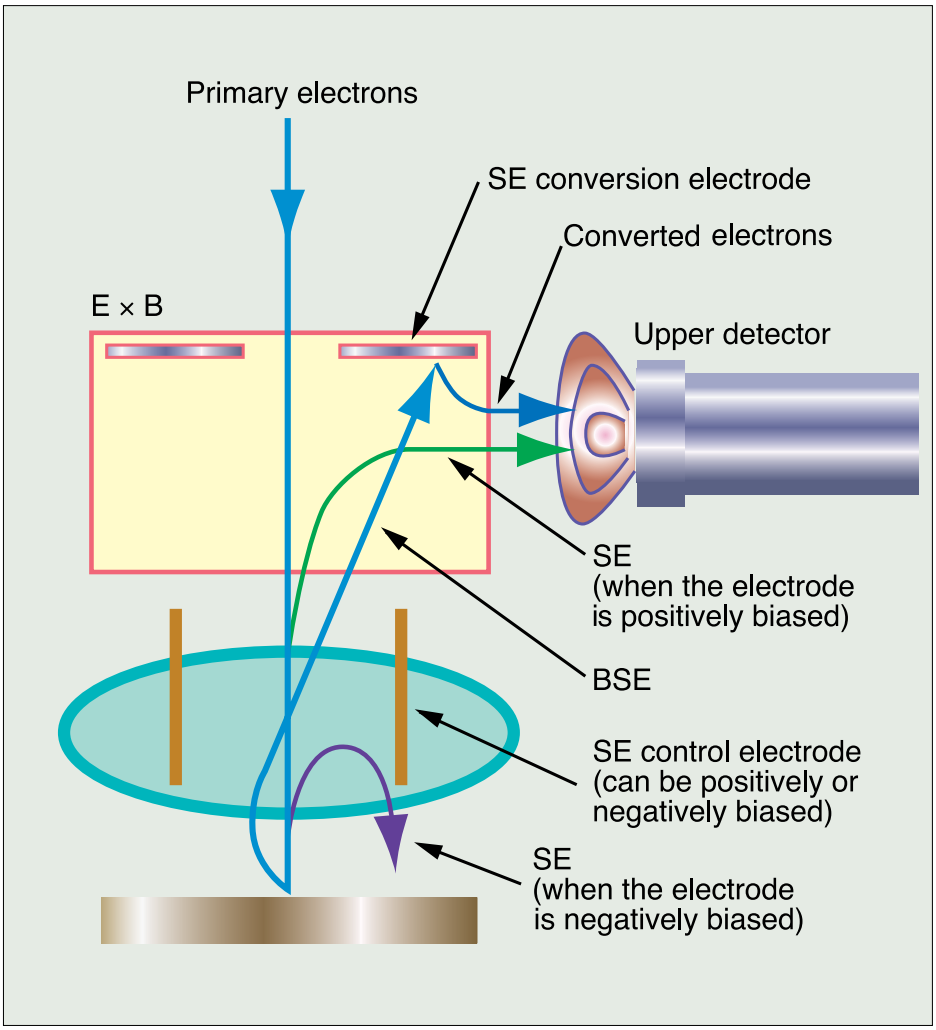




*High resolution micrograph of gold coated magnetic tape, recorded at 0.5 kV and WD of 2.5 mm, courtesy of Nissei Sangyo America, U. S. A.*

# Integrated Electron Detecto

*The S-4700 has a new and unique electron detector with signal manipulation design, encompassing secondary electron (SE) and backscattered electron (BSE) detectors in a single unit as illustrated at right. Operators can choose SE, BSE or both of them for the best imaging of their samples. This unique detector utilizes an E × B filter to enhance signal collection without interference from the primary electron beam. The E × B filter performs energy selection by change of electric fields across the electrodes in front of the detector or by change of magnetic flux across the electric fields. This design allows collection of SE and BSE separately or both at the same time. It has excellent DQE or detector quantum efficiency for high collection rates. Shown below and on the following page are typical micrographs recorded using the unique electron detector. We trust that you will appreciate the high performance and useful functions of the unique detector design.*

***Construction of a new E × B filter.***



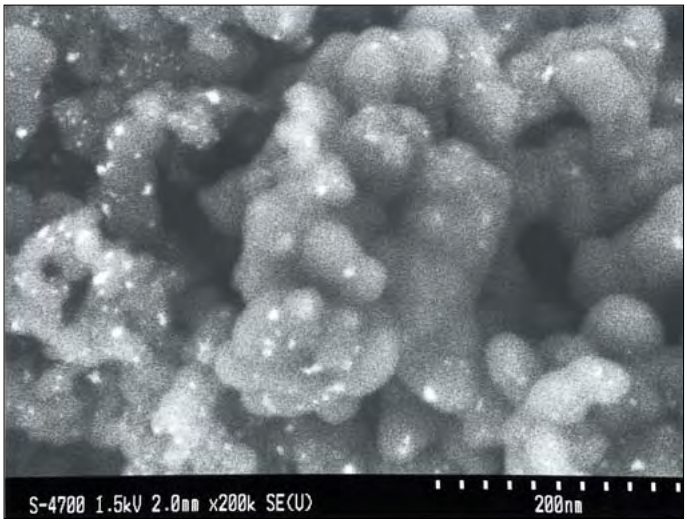

***Characteristic features of SE and BSE images***

| *SE image* | *BSE image* |
|---|---|
| ● *Sensitive to surface information* | ● *Sensitive to compositional information* |
| ● *High spatial resolution* | ● *Internal information available* |
| ● *Sensitive to voltage contrast* | ● *Less sensitive to surface charging* |
| | ● *Less sensitive to edge contrast* |

# or Design for SE and BSE

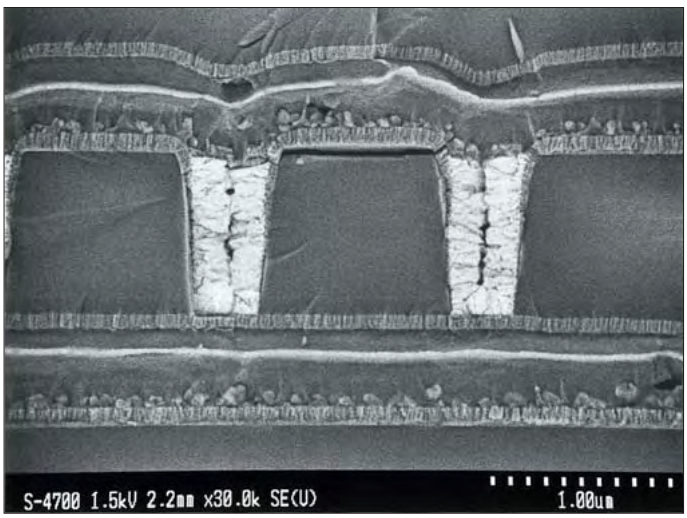
S-4700

***The surface image (left) and the composition image (right)*** *Specimen: Pt/C catalyzer*

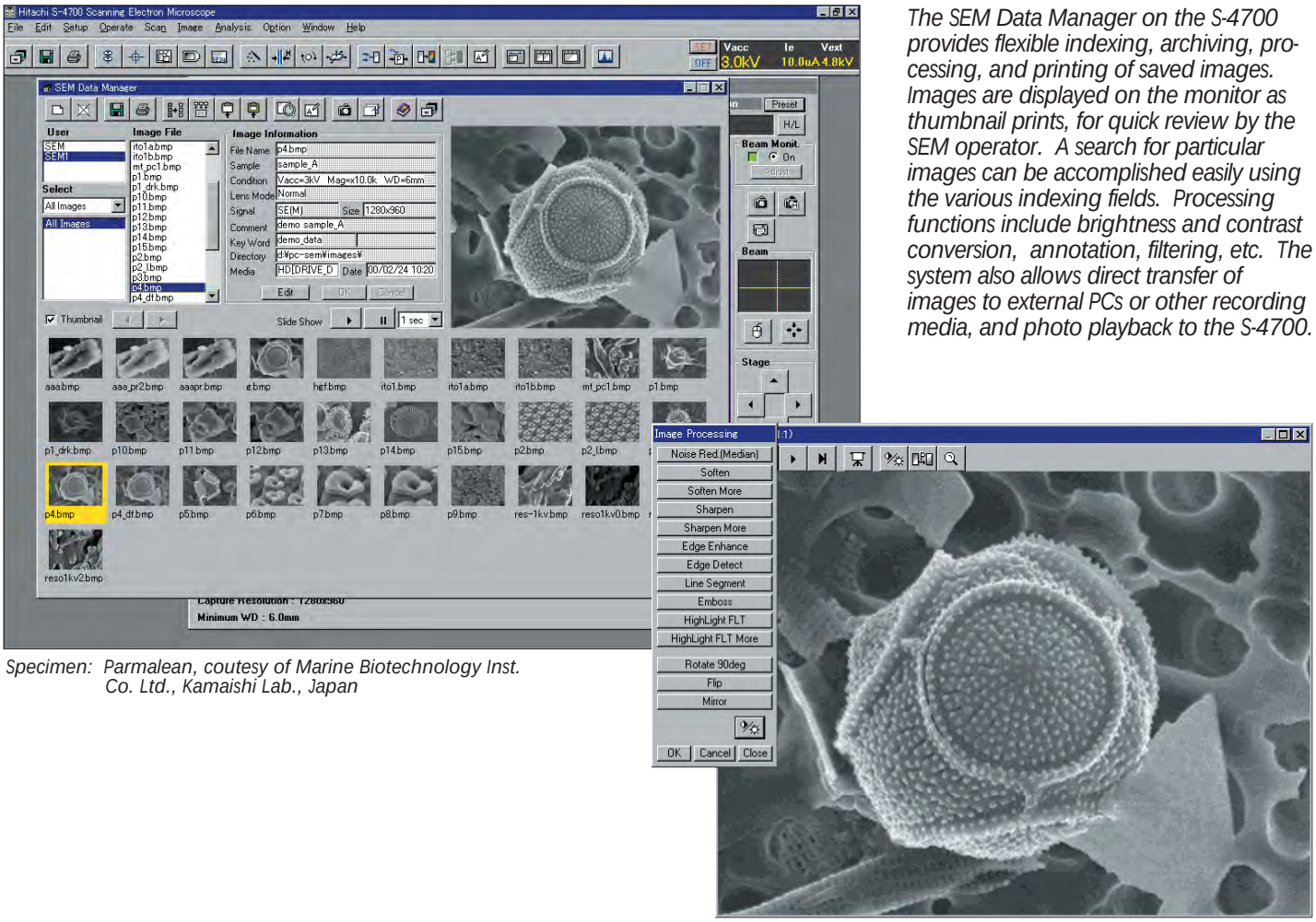

*The SE image shows topographic details of the specimen surface at high resolution.*
*The SE + BSE image shows specimen compositions reflecting atomic number contrast.*

***The SE image with less edge contrast and less charging artifact*** *Specimen: Cross-section of a microprocessor chip*


*With a normal SE image (left), it is difficult to observe fine surface details due to edge contrast and charging artifact.*
*With an SE + BSE image, it is easy to observe the surface details with enhanced compositional contrast.*

# Filing / Printing

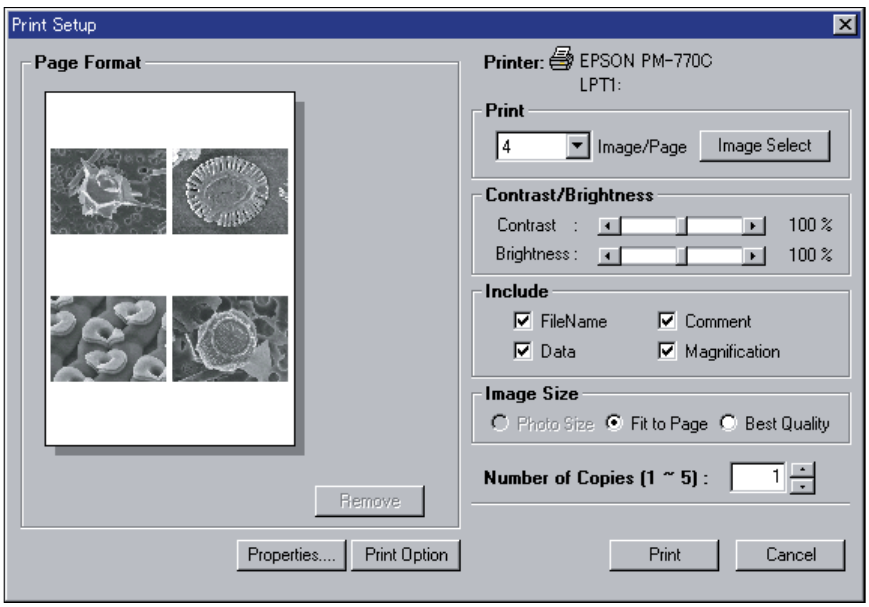



*Specimen: Parmalean, coutesy of Marine Biotechnology Inst. Co. Ltd., Kamaishi Lab., Japan*

*The SEM Data Manager on the S-4700 provides flexible indexing, archiving, processing, and printing of saved images. Images are displayed on the monitor as thumbnail prints, for quick review by the SEM operator. A search for particular images can be accomplished easily using the various indexing fields. Processing functions include brightness and contrast conversion, annotation, filtering, etc. The system also allows direct transfer of images to external PCs or other recording media, and photo playback to the S-4700.*

### *Printing*

*Image Manager includes a print function, as seen on the right, for printing of up to 8 images on one sheet. File names and comments can also be printed with the images as well.*



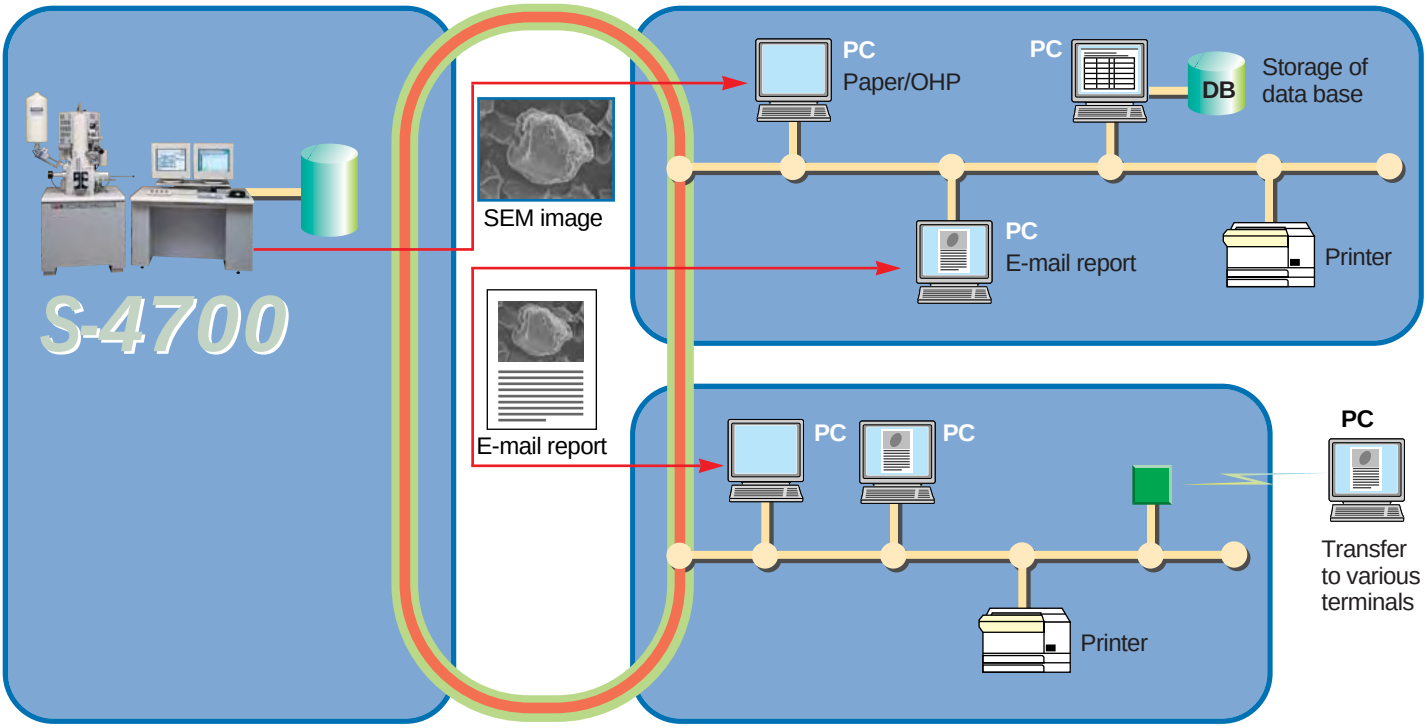
# Networking / Desk-Top-Publishing

S-4700

## Networking

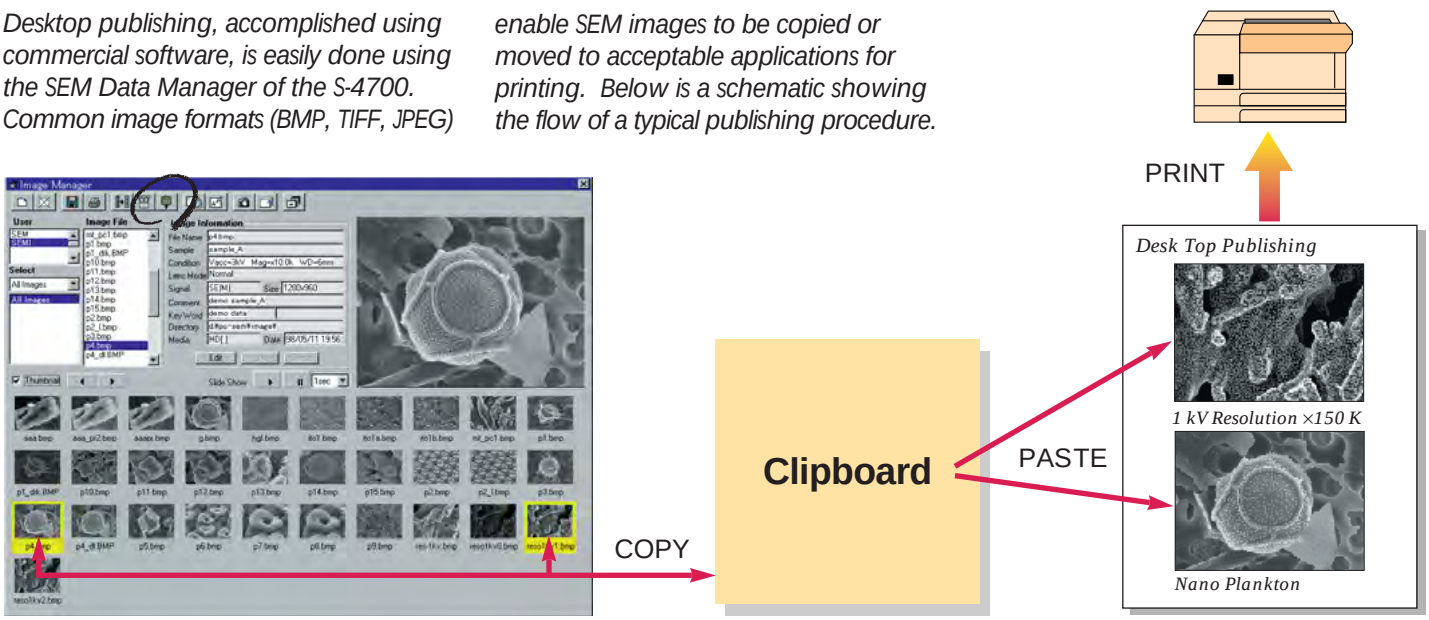
*The S-4700 has been designed to work within a network. The SEM images can be transferred to PCs and other servers.*

*The SEM image database (PCI) is available for remote PCs to permit the same image processing and searching capabilities typically done on the S-4700. This allows versatile use of the images, and respective data, acquired on the S-4700.*

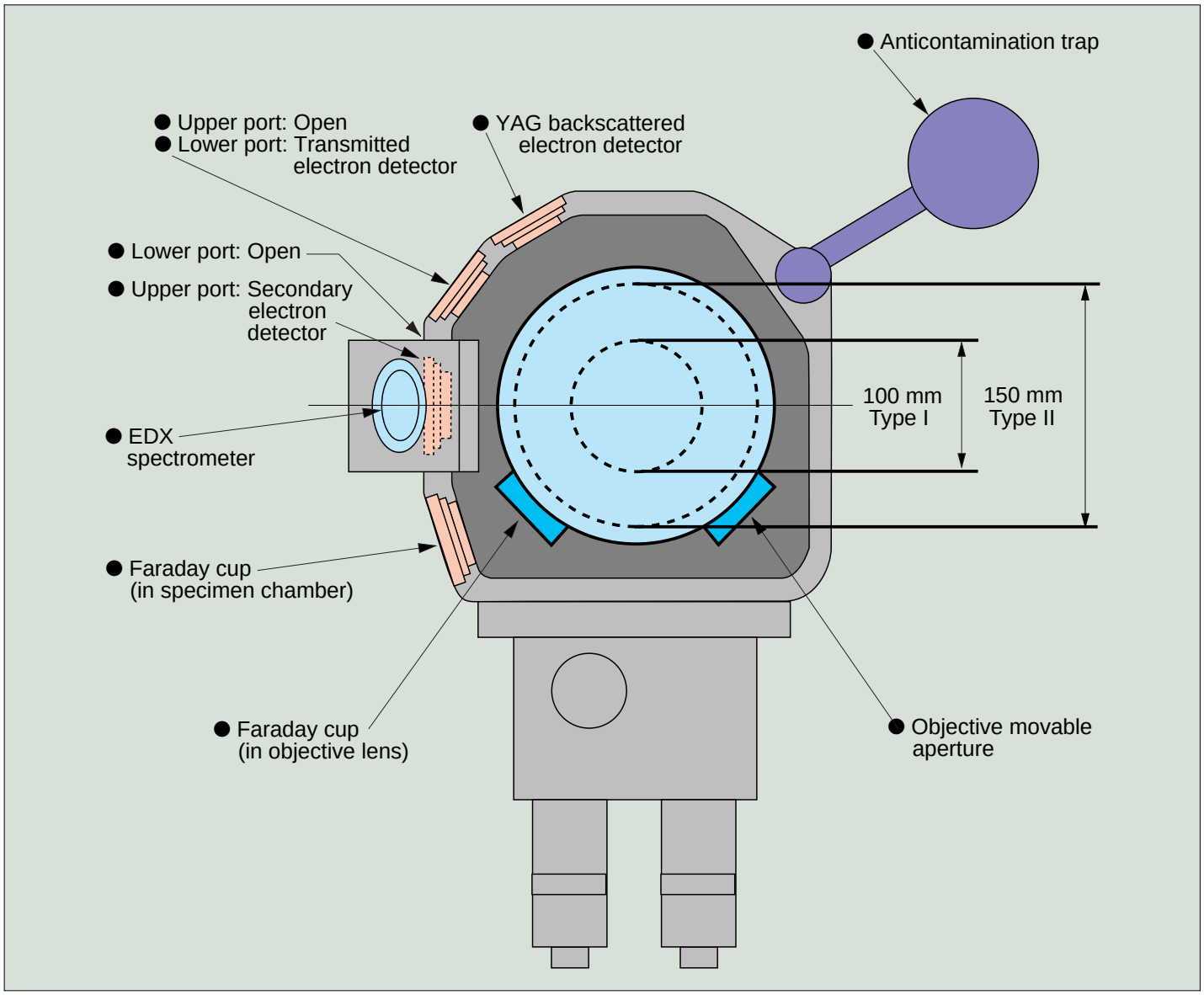



## Desk-Top-Publishing

*Desktop publishing, accomplished using commercial software, is easily done using the SEM Data Manager of the S-4700. Common image formats (BMP, TIFF, JPEG) enable SEM images to be copied or moved to acceptable applications for printing. Below is a schematic showing the flow of a typical publishing procedure.*

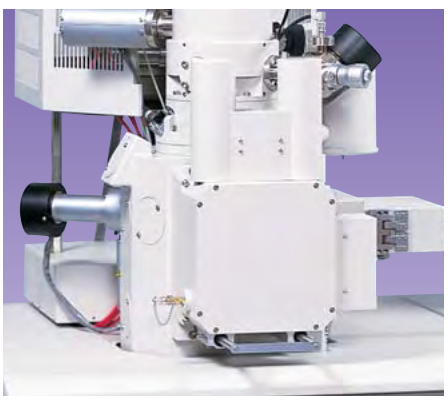


# Large Specimen Chamber




*The S-4700 has a large and versatile specimen chamber as illustrated above. Depending on the specimens and applications, SEM users can choose either a large or small specimen stage, as shown on the right. Various accessories, such as a backscattered electron detector, cryogenic system, or energy dispersive X-ray spectrometer, can be accommodated with the S-4700 chamber. These accessories extend the use of the S-4700, for a wide range of analysis possibilities.*

*Type I*



*Type II*

# Elemental Microanalysis

S-4700

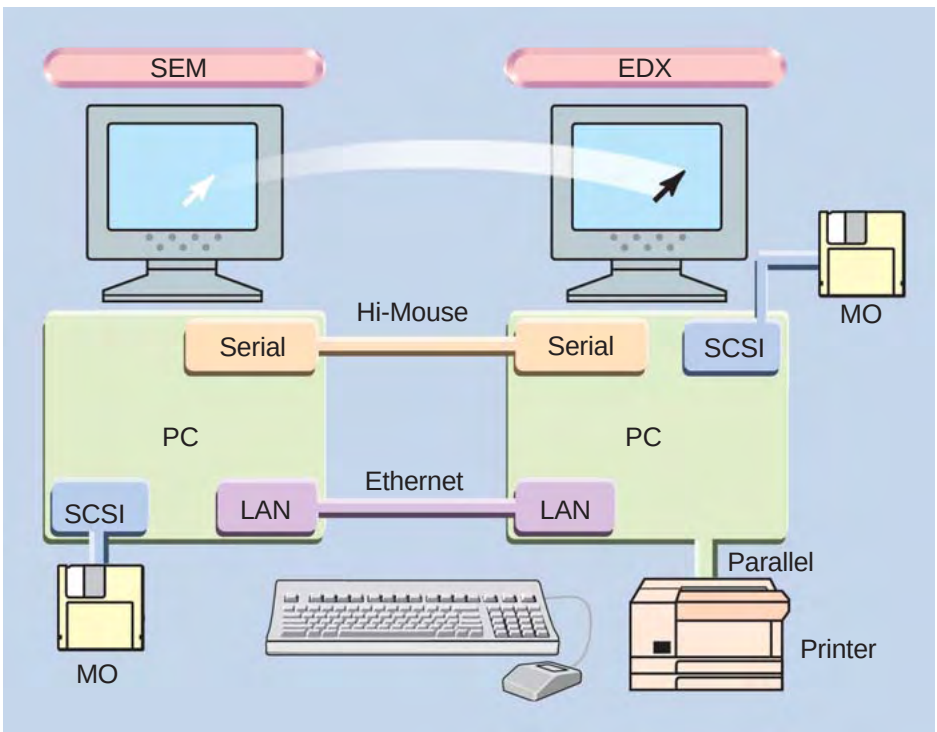
*Elemental analysis, utilizing an energy dispersive X-ray spectrometer, is available with the S-4700. Due to the automated column set-up, SEM operators do not need to adjust the column for X-ray work. A higher probe current is available with the click of a mouse, eliminating the need to vary the objective aperture or emission current. Another unique feature is available, called Hi-Mouse. Using the Hi-Mouse software, one keyboard and one mouse control both the EDX and SEM systems. The mouse is simply dragged between the two monitors to activate operation in each system, allowing display of both the elemental spectrum and SEM image, without additional hardware.*


## Hitachi SEM/EDX Integrated System Using Hi-Mouse

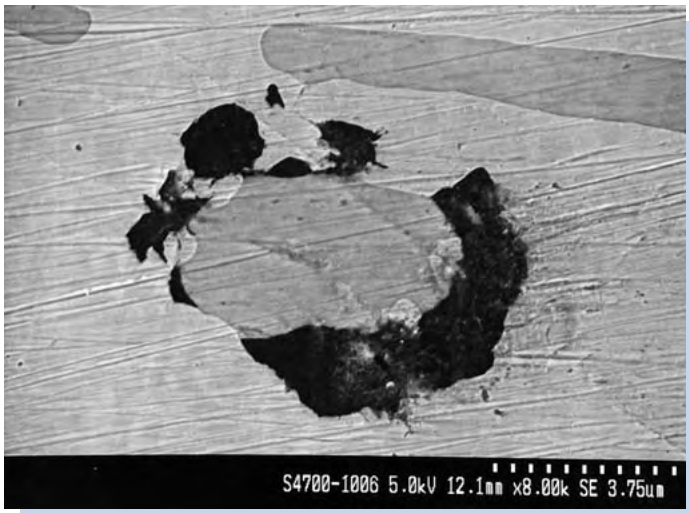
***Features:***

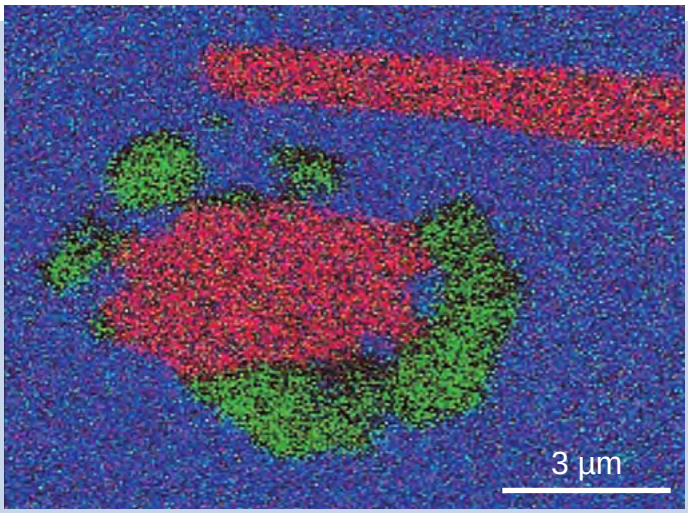
1. ***The SEM mouse and keyboard drive EDX system***
2. ***The 2 monitor/2 PC system allows display of both EDX spectrum and SEM image respective monitors at all times.***
3. ***SEM and EDX files are compatible.***
4. ***External recording media and printers are compatible***
5. ***Available with most EDX manufacturers.***

*Note: *1. Ethernet is a trademark of Xerox Corporation, USA*
**2. LAN connection is required for two PCs (option).*



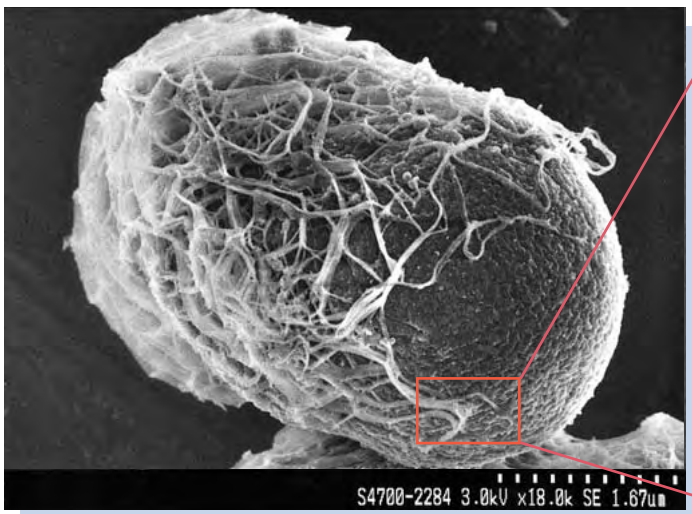
# Applications

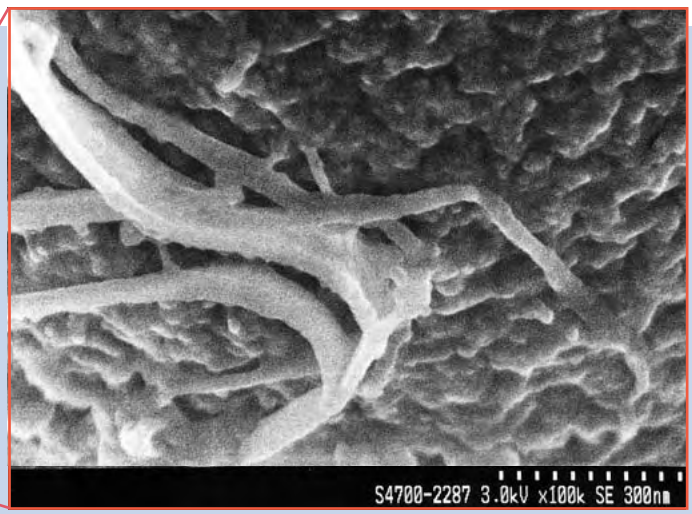


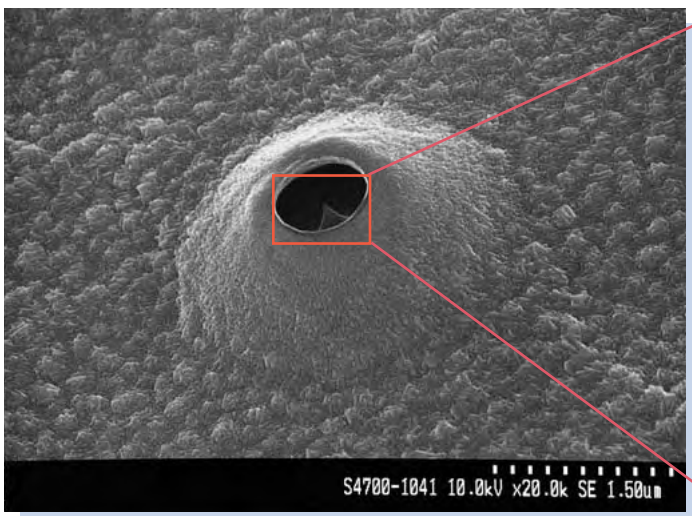

*Specimen: Scr 420 with 60 ppm B, courtesy of Daido Steel Co., Ltd., Research & Development Laboratory, Japan*

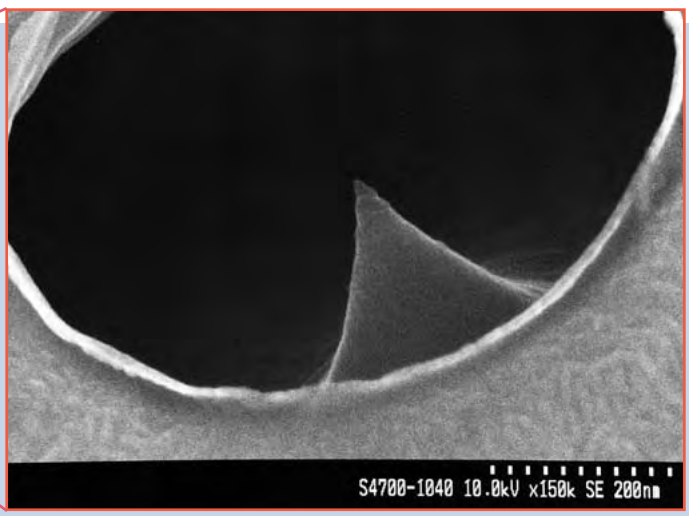
*X-ray mapping image (Red: S, Blue: Fe, Green: B)*




*Specimen: Regenerating glucan network of fission yeast protoplast, courtesy of Prof. Masako Osumi, Division of Chemical and Biological Science, Graduate School, Japan Women's University, Japan*




*Specimen: Field emitter*

# Specifications

S-4700

**Secondary electron image resolution**
2.1 nm guaranteed (at 1 kV)
1.5 nm guaranteed (at 15 kV and W.D. 12 mm or X-ray analysis position)

**Backscattered electron image resolution**
3.0 nm guaranteed (at 15 kV YAG detector, option)

**Electron optics**

| | |
|---|---|
| Electron gun | Cold field emission electron source |
| Acc. voltage | 0.5 ~ 30 kV (variable at 0.1 kV/step) |
| Probe current | 1 pA ~ 2 nA (depends on Acc. voltage) |
| Magnification | ×20 ~ ×500,000 |
| Objective aperture | Heated movable aperture, 4-opening, selectable and alignable outside the vacuum |

| Specimen stage | | Type I | Type II |
|---|---|---|---|
| Traverse | X: | 0 ~ 25 mm | 0 ~ 100 mm |
| | Y: | 0 ~ 25 mm | 0 ~ 50 mm |
| | Z: | 1.5 ~ 26.5 mm | 1.5 ~ 30.0 mm |
| | T: | –5 ~ +45 degrees | –5 ~ +60 degrees |
| | R: | 360 degrees | 360 degrees |
| | Drive | Manual | PC-controlled 5-axis motor-drive |
| Specimen exchange | | 100 mm dia.×17 mm(t) | 150 mm dia.×6 mm(t) |

**Image display**

| | |
|---|---|
| Operation/display | OS: Microsoft® Windows® XP Professional<br>Large color CRT |
| Scan mode | Normal, Split/dual mag./line scan, position set, spot, AAF, SAA, oblique |
| Frame memory | 640 × 480 pixels, 1,280 × 960 pixels, 2,560 × 1,920 pixels |
| Image filing | Image data base with various reference functions built-in |
| Image file format | BMP, TIFF, JPEG selectable |
| Scan speed | TV, slow (0.5 ~ 40 s/frame) for viewing<br>Slow (40 ~ 320 s/frame) for recording |
| Image processing | Automatic image brightness & contrast, raster rotation, autofocus, auto-stigmation, averaging, frame integration, color display |
| Auto data recording | Film numbering, acc. voltage, micron bar with a scale, magnification, date, hours and working distance |

**Electrical image shift** ±15 microns (at W.D = 12 mm)

**Vacuum system**

| | |
|---|---|
| System | Automatic vacuum sequence with pneumatic valve controls |
| Vacuum | ~$10^{-7}$ Pa (electron gun),<br>~$10^{-4}$ Pa (specimen chamber) |
| Pumps | Fore pumps 140 l/min (168 l/min) × 2 sets, ( )is for 60 Hz operation.<br>Diffusion pump 570 l/s × 1 set,<br>and Ion pumps × 3 sets |
| Protection | System protection against power, water and vacuum failures. |

* Microsoft® and Windows® are registered trademark of Microsoft Corporation, U.S.A.

## Dimensions & weight

| | |
|---|---|
| Column | 82 × 88 × 165 (H) cm, 410 kg<br>(for type II stage) |
| Display | 120 × 90 × 137(H) cm, 235 kg |
| Ion pump power supply | 37 × 60 × 60 (H) cm, 75 kg |
| Power unit | 39 × 70 × 47 (H) cm, 35 kg |

## Optional accessories

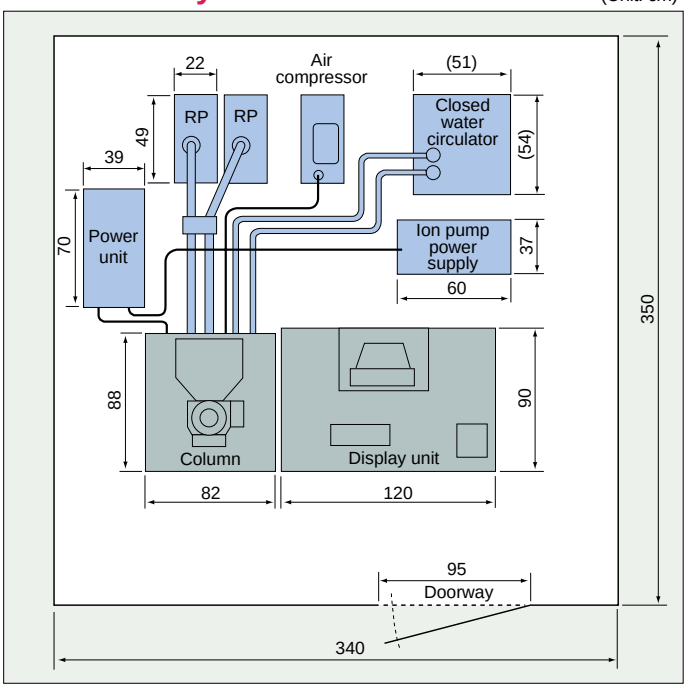
| | |
|---|---|
| Specimen stages (for type I) | Cryogenic stage, IC stage, EBIC image observation system, Tensile stage, 2-axis motor drive unit |
| Detectors | YAG BSE detector, Transmitted electron detector |
| Display | Video amplifier software, Photo multiplier power supply unit, DBC interface, Measurement function |
| Others | Photo CRT, various recording cameras, EDX system, TMP vacuum system, Closed water circulator, Image printer, and Remote operation software for EDX "Hi-mouse" and Expansive operation panel with function controls, RS-232C comunication interface, network interface. |

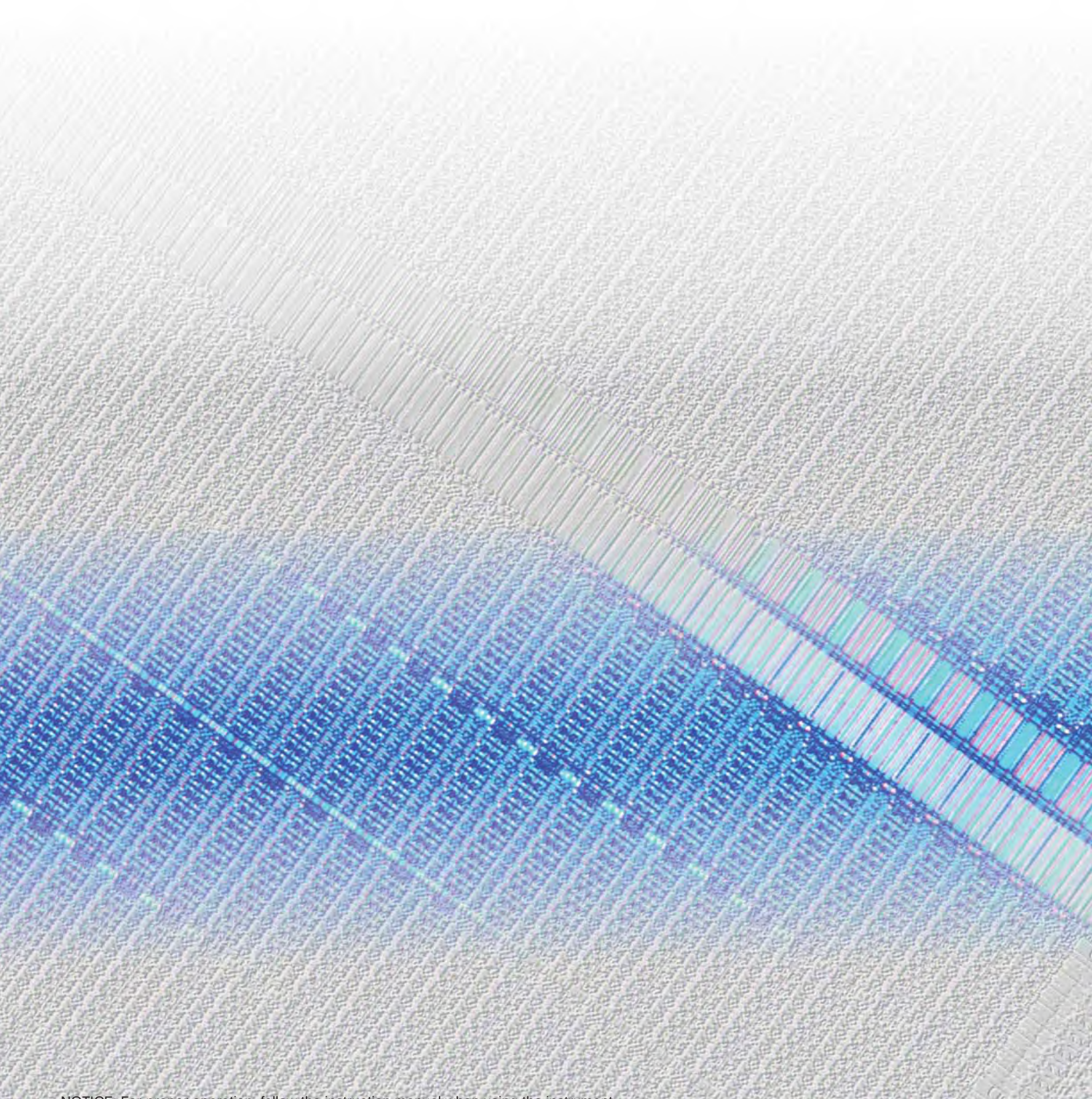
## Installation utility requirements

| | |
|---|---|
| Room temperature: | 15 ~ 25 °C or 59 ~ 77 °F |
| Relative humidity: | 60% or less |
| Power: | Single phase AC 100, 110, 115, 200, 220, 240V ±10%, 50/60 Hz, 4 kVA (Continuous supply is required.) |
| Grounding: | First grade grounding (Grounding resistance of 100 ohms or less) × 1 |
| Cooling water: | 1.5 ~ 2.0 l/min., 50 ~ 100 kPa<br>10 ~ 20 °C, variation within<br>0.5 °C/10 min. |

## Installation layout

(Unit: cm)





NOTICE: For proper operation, follow the instruction manual when using the instrument.

Specifications in this catalog are subject to change with or without notice, as Hitachi High-Technologies Corporation continues to develop the latest technologies and products for our customers.

**Hitachi High-Technologies Corporation**
**Tokyo, Japan**
**http://www.hitachi-hitec.com**
24-14 Nishi-Shimbashi 1-chome, Minato-ku, Tokyo, 105-8717, Japan

*For further information, please contact your nearest sales representative.*

Printed in Japan(H) **HTD–E010Q** 2004.11